

**WHAT IS CLAIMED IS:**

1 1. A fuel properties estimating apparatus for an internal  
2 combustion engine, the fuel properties estimating  
3 apparatus comprising:

4 a controller to determine an estimated component  
5 concentration of a component in a fuel for the engine, the  
6 controller being configured,

7 to calculate an air-fuel correction quantity for  
8 correcting a fuel supply quantity for the engine, in  
9 accordance with an actual air fuel ratio of the engine;

10 to calculate a fuel properties correction quantity in  
11 accordance with a most recent value of the component  
12 concentration;

13 to calculate an air-fuel ratio sensitivity correction  
14 quantity from the air-fuel ratio correction quantity and the  
15 fuel properties correction quantity; and

16 to calculate a new value of the estimated component  
17 concentration in accordance with the air-fuel ratio  
18 sensitivity correction quantity.

1 2. The fuel properties estimating apparatus as claimed  
2 in Claim 1, wherein the air-fuel correction quantity  
3 comprises an air-fuel ratio feedback correction coefficient  
4 calculated in accordance with the actual air fuel ratio  
5 sensed by an air-fuel ratio sensor.

1 3. The fuel properties estimating apparatus as claimed  
2 in Claim 1, wherein the air-fuel correction quantity

3 comprises an air-fuel ratio learning correction quantity  
4 calculated in accordance with the actual air fuel ratio.

1 4. The fuel properties estimating apparatus as claimed  
2 in Claim 1, wherein the controller is configured to detect a  
3 failure of a fuel system for the engine, and to set the  
4 estimated component concentration at a provisional fixed  
5 value when a failure in the fuel system is detected.

1 5. The fuel properties estimating apparatus as claimed  
2 in Claim 1, wherein the controller is configured to increase  
3 the estimated component concentration in proportion to the  
4 air-fuel ratio sensitivity correction quantity when the actual  
5 air-fuel ratio is on a lean side with respect to a  
6 stoichiometric ratio.

1 6. The fuel properties estimating apparatus as claimed  
2 in Claim 1, wherein the controller is configured to hold the  
3 estimated component concentration substantially constant  
4 without regard to variation in the air-fuel ratio sensitivity  
5 correction quantity in a predetermined region of the air fuel  
6 ratio sensitivity correction quantity on a lean side of the  
7 actual air-fuel ratio with respect to a stoichiometric ratio.

1 7. The fuel properties estimating apparatus as claimed  
2 in Claim 6, wherein the controller is configured to  
3 determine the estimated component concentration with a  
4 dead band to hold the estimated component concentration  
5 substantially constant without regard to variation in the

6 air-fuel ratio sensitivity correction quantity in the  
7 predetermined region conform to a commercially available  
8 blend fuel.

1 8. The fuel properties estimating apparatus as claimed  
2 in Claim 6, wherein the controller is configured to  
3 determine a first component concentration and a second  
4 component concentration as the estimated component  
5 concentration in accordance with the air-fuel ratio  
6 sensitivity correction quantity; to increase the first  
7 component concentration in proportion to the air-fuel ratio  
8 sensitivity correction quantity; and to determine the second  
9 component concentration with a dead band to hold the  
10 second component concentration substantially constant  
11 without regard to variation in the air-fuel ratio sensitivity  
12 correction quantity in the predetermined region of the air  
13 fuel ratio sensitivity correction quantity.

1 9. The fuel properties estimating apparatus as claimed  
2 in Claim 8, wherein the controller is configured to use the  
3 first component concentration for control of a first  
4 combustion parameter of the engine, and the second  
5 component concentration for control of a second  
6 combustion parameter of the engine.

1 10. The fuel properties estimating apparatus as claimed  
2 in Claim 9, wherein the second combustion parameter is  
3 one of a wall flow correction, a cold enrichment quantity, a  
4 target air-fuel ratio and an ignition timing.

1 11. The fuel properties estimating apparatus as claimed  
2 in Claim 9, wherein the first combustion parameter is a  
3 basic fuel injection quantity for the engine.

1 12. The fuel properties estimating apparatus as claimed  
2 in Claim 1, wherein the controller is configured to examine  
3 whether the air-fuel ratio correction quantity is outside a  
4 predetermined region; and to determine the estimated  
5 component quantity when the air-fuel ratio correction  
6 quantity is outside the predetermined region.

1 13. The fuel properties estimating apparatus as claimed  
2 in Claim 12, wherein the controller is configured to examine  
3 an engine operating condition to determine whether a first  
4 permitting condition is satisfied; to determine that a  
5 second permitting condition is satisfied when the air-fuel  
6 ratio correction quantity is outside the predetermined  
7 region; and to refrain from calculating a new value of the  
8 estimated component concentration when the first  
9 permitting condition is not satisfied and at the same time  
10 the second permitting condition is not satisfied.

1 14. The fuel properties estimating apparatus as claimed  
2 in Claim 13, wherein the controller is configured to  
3 determine a first component concentration and a second  
4 component concentration as the estimated component  
5 concentration in accordance with the air-fuel ratio  
6 sensitivity correction quantity; and the controller is further

7 configured to determine new values of the first and second  
8 component concentrations when the first permitting  
9 condition is satisfied, and to determine the new value of  
10 the first component concentration without determining a  
11 new value of the second component concentration when the  
12 first permitting condition is not satisfied and the second  
13 permitting condition is satisfied.

1 15. The fuel properties estimating apparatus as claimed  
2 in Claim 14, wherein the controller is configured to increase  
3 the first component concentration in proportion to the  
4 air-fuel ratio sensitivity correction quantity; and to  
5 determine the second component concentration with a dead  
6 band to hold the second component concentration  
7 substantially constant without regard to variation in the  
8 air-fuel ratio sensitivity correction quantity in a  
9 predetermined region of the air fuel ratio sensitivity  
10 correction quantity on a lean side of the actual air-fuel  
11 ratio with respect to a stoichiometric ratio.

1 16. The fuel properties estimating apparatus as claimed  
2 in Claim 12, wherein the controller is configured to  
3 conclude that the first permitting condition is not satisfied  
4 when a disturbance exerting influence on an exhaust  
5 air-fuel ratio of the engine is present, and wherein the  
6 controller is configured to conclude that the disturbance is  
7 present when a quantity of a blowby gas is greater than or  
8 equal to a predetermined value.

1 17. The fuel properties estimating apparatus as claimed  
2 in Claim 12, wherein the controller is configured to examine  
3 whether the air-fuel ratio correction quantity is outside the  
4 predetermined region which is bounded between an upper  
5 limit greater than one and a lower limit smaller than one.

1 18. The fuel properties estimating apparatus as claimed  
2 in Claim 1, wherein the component in the fuel for the  
3 engine is alcohol.

1 19. A fuel properties estimating process for determining  
2 an estimated component concentration of a component in a  
3 fuel for an internal combustion engine, the fuel properties  
4 estimating process comprising:  
5       calculating an air-fuel correction quantity for  
6       correcting a fuel supply quantity for the engine, in  
7       accordance with an actual air fuel ratio of the engine;  
8       calculating a fuel properties correction quantity in  
9       accordance with a most recent value of the component  
10      concentration;  
11      calculating an air-fuel ratio sensitivity correction  
12      quantity from the air-fuel ratio correction quantity and the  
13      fuel properties correction quantity; and  
14      calculating a new value of the estimated component  
15      concentration in accordance with the air-fuel ratio  
16      sensitivity correction quantity.

1 20. A fuel properties estimating apparatus for an internal  
2 combustion engine, the fuel properties estimating  
3 apparatus comprising:  
4 an air-fuel ratio sensor to sense an actual exhaust  
5 air-fuel ratio of the engine; and  
6 a controller to determine an estimated component  
7 concentration of a component in a fuel for the engine in  
8 accordance with a control parameter determined from the  
9 actual exhaust air-fuel ratio, the controller being  
10 configured to determine the estimated component  
11 concentration with a dead band to hold the estimated  
12 component concentration substantially constant without  
13 regard to variation in the control parameter in a  
14 predetermined region of the control parameter.

1 21. A fuel properties estimating apparatus for an internal  
2 combustion engine, the fuel properties estimating  
3 apparatus comprising:  
4 an air-fuel ratio sensor to sense an actual exhaust  
5 air-fuel ratio of the engine; and  
6 a controller to determine an estimated component  
7 concentration of a component in a fuel for the engine in  
8 accordance with the actual exhaust air-fuel ratio, the  
9 controller being configured to calculate an air-fuel  
10 correction quantity for correcting a fuel supply quantity for  
11 the engine, in accordance with the actual air fuel ratio of  
12 the engine; to examine whether the air-fuel ratio correction  
13 quantity is outside a predetermined region; and to  
14 determine the estimated component quantity when the

- 15 air-fuel ratio correction quantity is outside the
- 16 predetermined region.